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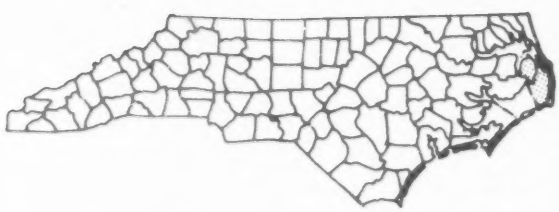
COMPLETED

FLOOD INSURANCE STUDY

ORIGINAL

TOWN OF KILL DEVIL HILLS,
NORTH CAROLINA
DARE COUNTY



FEBRUARY 19, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER - 375353

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Flood Insurance Rate Map

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FLOOD INSURANCE STUDY
TOWN OF KILL DEVIL HILLS
DARE COUNTY
NORTH CAROLINA

1.0 INTRODUCTION

1.1 Purpose of Study

The purpose of this Type 19 Flood Insurance Study is to investigate the existence and severity of flood hazards remaining in the Town of Kill Devil Hills, Dare County, North Carolina, and to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. Initial use of this information will be to revise Flood Insurance Rate Maps developed from data presented in the Type 15 Flood Insurance Study. Further use of the information will be made by local and regional planners in their efforts to promote sound land use and floodplain management.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these Federally supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the floodplain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3(e). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Tetra Tech, Inc. (Study Contractor) for the Federal Emergency Management Agency, under Contract No. EMW-C-0344. This study was completed in February 1984.

1.3 Coordination

The following organizations were contacted for coordination in the development of this study:

County of Dare, North Carolina
Eastern Mapping Center, U.S. Geological Survey
Reston, Virginia
North Carolina Department of Transportation
North Carolina Geodetic Survey
Town of Kill Devil Hills, North Carolina
U.S. Army Corps of Engineers, Wilmington, North Carolina
U.S. Department of Agriculture, Soil Conservation Service
U.S. Department of Commerce, Bureau of the Census
Henry von Oesen and Associates

The State Coordinator was involved with this study through the Region IV Office of the Federal Emergency Management Agency.

On January 8, 1985, the results of this study were reviewed at a final coordination meeting attended by representatives of the study contractor, FEMA, and community officials. The study was acceptable to the community.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Town of Kill Devil Hills. The area of study is shown on the Vicinity Map (Figure 1). This detailed study includes coastline flooding due to hurricane induced storm surge. Both the open coast surge and its inland propagation were studied; in addition, the added effects of wave heights were also considered.

The Atlantic Ocean, Roanoke Sound, and Colington Creek are the only flooding sources in Kill Devil Hills studied by detailed methods. Flooding or ponding from local runoff is minimal, even during extreme storms. The areas studied by detailed methods were selected with priority given to all known flood hazard areas, and areas of projected development or proposed construction for the next five years, through February 1989.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to and agreed upon by the Federal Emergency Management Agency and the Town of Kill Devil Hills.

2.2 Community Description

The Town of Kill Devil Hills is located on Bodie Island in Dare County, northeastern North Carolina. This island is one link in the barrier beach chain of the Atlantic Seaboard, and lies approximately 9 miles off the mainland. It is connected to the mainland by U.S. Highways 64 and 264 which bridge Roanoke and Croatan Sounds, and U.S. Highway 158 which bridges Currituck Sound. The Town is about 4.5 miles long and its width varies from 0.7 mile to 1.9 miles (Reference 1). The Town of Nags Head borders to the south, the Town of Kitty Hawk to the north, the Atlantic Ocean to the east, and the unincorporated areas of Dare County to the west.

The 1970 U.S. Bureau of the Census recorded the population of Kill Devil Hills at 357. The 1980 Census recorded the population of Kill Devil Hills at 1,796, a 403.1 percent increase over the 1970 population figure (Reference 2).

The topography of Kill Devil Hills is relatively flat with elevations ranging from sea level to 15 feet above the National Geodetic Vertical Datum (NGVD) (Reference 3).

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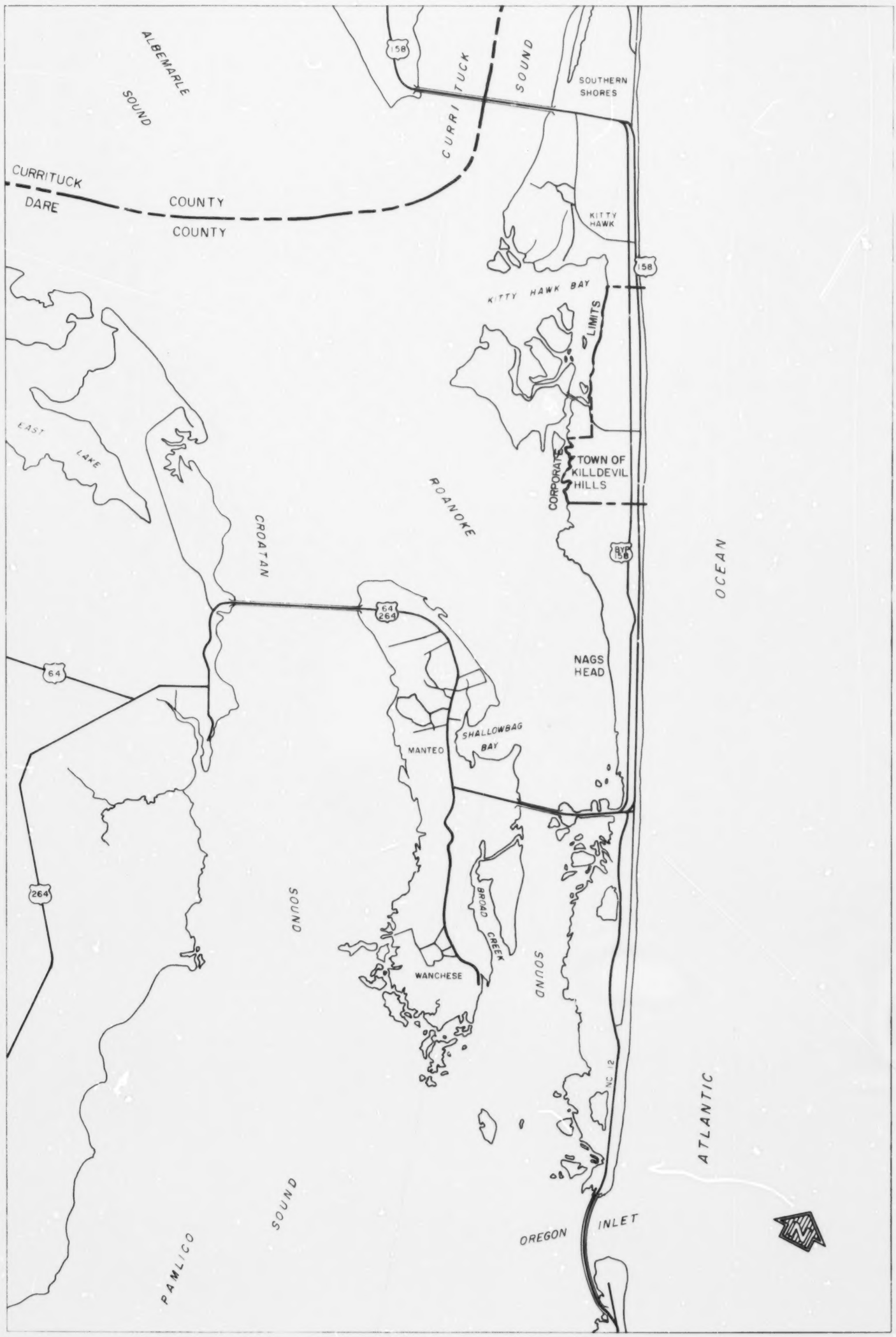

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF KILL DEVIL HILLS, NC
(DARE CO)

APPROXIMATE SCALE
2 0 2 4 6 Miles

VICINITY MAP

3

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Kill Devil Hills relies heavily on tourism as the main source of outside income. The main economic impacts of the recreation industry stem from the direct effect of tourist expenditures. Construction, agriculture, forestry and fisheries, manufacturing, and transportation also play an important part in the Town's economy (Reference 4).

The climate of Kill Devil Hills is characterized by mild winters and warm summers. The average annual temperature in the study area is approximately 61 degrees fahrenheit. Average annual precipitation in the region is approximately 43 inches with the heaviest rains usually occurring during the summer months (Reference 4).

The Newhan-Corolla-Duckston Association is the only soil association located in Kill Devil Hills. This soil association is described as excessively drained to poorly drained sands of the Coastal Beach regions (Reference 5).

2.3 Principal Flood Problems

The dominant source of flooding in Kill Devil Hills is storm surge generated in the Atlantic Ocean by tropical storms and hurricanes. In addition, this surge propagates into Roanoke Sound and Colington Creek where high winds associated with tropical storms can produce high waves. The wave action associated with storm surge can be much more damaging than the higher water level. Not all storms which pass close to the study area produce extremely high surge. Similarly, storms which produce flooding conditions in one area may not necessarily produce flooding conditions in other parts of the study area.

North Carolina experiences hurricanes, tropical storms, and severe extratropical cyclones usually referred to as northeasters. Unlike a hurricane which may pass over a coastal location in a fraction of a day, a northeaster may blow from the same direction and over long distances for several days (Reference 6). The contribution from northeasters to the overall storm surge elevation in the Kill Devil Hills area was found to be significant.

Storms passing North Carolina in the vicinity of Kill Devil Hills have produced severe floods as well as structural damage. Brief descriptions of several significant storms provide historical information to which coastal flood hazards and flood depths can be compared (Reference 7).

October 5 to 18, 1954 (Hurricane Hazel)

Hurricane Hazel was the most destructive storm in the history of North Carolina. The storm crossed the coast just north of Myrtle Beach, South Carolina, as hurricane winds hit the Atlantic coast between Georgetown, South Carolina, and Cape Lookout, North Carolina. Storm tides (i.e. hurricane surge) devastated the immediate ocean front of this stretch of coast. Every fishing pier along 170 miles of coast, from Myrtle Beach, South Carolina

to Cedar Island, North Carolina, was destroyed. The waterfront between the South Carolina - North Carolina state line and Cape Fear was completely destroyed. Grass-covered dunes, some 20 feet high, along and behind which beach homes had been built in a continuous line 5 miles long, simply disappeared - dunes, houses, and all. From Cape Fear to Cape Lookout the degree of devastation was not as great, but ocean front property was damaged an average of 50 percent along this entire stretch. North of Cape Lookout damage was relatively light.

Storm surge of 16.6 feet above National Geodetic Vertical Datum (NGVD) was observed at Holden Beach Bridge and Calabash, North Carolina. The lowest recorded barometric pressure of the storm was 938 millibars (mb), reported at Little River Inlet on the North Carolina - South Carolina border. Maximum wind speeds were 83 mph, with gusts recorded at 98 mph at Wilmington, North Carolina; 106 mph at Myrtle Beach, South Carolina; and an estimated 150 mph at Cape Fear. The storm continued inland through North Carolina causing widespread damage due to high winds and record rainfall. Nineteen people were killed and 200 injured during this storm.

August 3 to 14, 1955 (Hurricane Connie)

Hurricane Connie entered North Carolina close to Cape Lookout at about 8:30 a.m. on August 12. The prolonged pounding of high waves against the coast caused tremendous beach erosion, probably worse than that caused by Hazel in 1954. Storm tides along the coast from Southport to Nags Head were reported to be about 7 feet NGVD (6.9 feet NGVD at Wrightsville Beach and 7.5 feet NGVD at Kure Beach). Water in sounds and near the mouths of rivers was 5 to 8 feet above normal. At Wilmington, winds were reported at 72 mph, gusting to 83 mph. At Fort Macon, winds of 75 mph, gusts of 100 mph, and a barometric pressure of 962 mb were reported. The storm also brought torrential rains with the maximum rainfall, around 12 inches in 48 hours, occurring near Morehead City. Total damage throughout the State was estimated at $50 million.

August 7 to 21, 1955 (Hurricane Diane)

Five days after Hurricane Connie, and before the damage from that storm could be estimated, Hurricane Diane struck the coast near Carolina Beach about 6 a.m. on August 17. The highest wind speed reported during this storm was 74 mph at Wilmington Airport. Storm tides ranged from 5 to 9 feet above mean low water on the beaches (6.8 feet NGVD at Wrightsville Beach), and in some areas of sounds and rivers emptying into sounds, estimated water levels were 5 to 9 feet above normal. Water was 3 feet above floor level in the business district of Belhaven and "waist deep" in parts of Washington and New Bern. Diane caused severe beach erosion along the North Carolina coast. The total damage caused in North Carolina by Connie and Diane was estimated to be in excess of $90 million. No deaths or injuries in North Carolina were attributed to either of the storms.

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September 10 to 23, 1955 (Hurricane Ione)

Hurricane Ione moved up from the south and crossed the North Carolina coast near Salter Path, 10 miles west of Morehead City, at about 5 a.m. on September 19. It then slowly curved to the northeast and went out to sea near the Virginia border early on September 20. When Ione entered North Carolina, winds gusted to over 100 mph. Wind speeds of 75 mph with gusts to 107 mph were recorded at Cherry Point. The minimum barometric pressure recorded over North Carolina during this storm was 960 mb. Heavy rains also accompanied Ione. At the same time, prolonged easterly winds drove tidal water onto beaches and into sounds and estuaries to heights of 3 to 10 feet above normal. The result was the largest inundation of eastern North Carolina ever known to have occurred. At New Bern, the depth of the flood was the greatest ever recorded, about 10.5 feet above mean low water; forty city blocks were flooded, several hundred homes were washed away, and thousands more were flooded with up to 4 feet of water. A high tide of 6.9 feet NGVD was reported at Atlantic Beach, North Carolina, and an estimated 5.3 feet NGVD at Wrightsville Beach.

September 21 to October 3, 1958 (Hurricane Helene)

Hurricane Helene was one of the most powerful storms of recent history; fortunately for the people of North Carolina, the storm center was well out at sea as it moved north on September 26 and 27. Nevertheless, high winds were recorded at Wilmington, with the highest winds measured at 85 mph and peak gusts recorded at 135 mph. The lowest reported central pressure of the storm was 932 mb; this measurement was recorded south-southeast of Cape Fear early on the morning of the 27th. There was some beach erosion due to seas and tides, but this erosion was minimized by the fact that the storm occurred at a time of low astronomical tides. High tides were estimated at 3 to 5 feet above normal; a high tide of 5.1 feet NGVD was reported at Wrightsville Beach. Tides were higher on the southern edge of Pamlico Sound, when the wind shift as the storm center passed brought the tides 7 to 8 feet above normal.

August 29 to September 13, 1960 (Hurricane Donna)

Hurricane Donna crossed the North Carolina coast between Wilmington and Morehead City on September 11, 1960. The center of the storm passed a few miles east of Wrightsville Beach, although Wilmington and Wrightsville Beach were each in the eye for about an hour. The lowest barometric pressure recorded during this storm was 962 mb at Wilmington. High tides, 6 to 8 feet above normal, together with high winds, caused severe damage at many points. Winds of hurricane force, up to 97 mph, were reported from Wilmington.

During the night of September 11, the storm center moved northward, parallel and slightly east of a line drawn between Wilmington and Norfolk. Wind gusts were in excess of 97 mph and tides were 4 to 8 feet above normal. High tides of 10.3 and 8.3

feet NGVD were reported at Atlantic Beach and Wrightsville Beach, respectively. Coastal communities from Wilmington to Nags Head suffered heavy structural damage and considerable beach erosion. Eight deaths and approximately 100 injuries were attributed to the storm. Damages were estimated at millions of dollars.

2.4 Flood Protection Measures

There are no structural flood protection measures in the Town of Kill Devil Hills (Reference 8). The only notable nonstructural flood protection measure is the Public Warning System for severe weather conditions operated by the National Oceanic and Atmospheric Administration, through the National Weather Service in cooperation with various state, county, and local officials. This system can provide some measure of flood protection by alerting coastal residents to take the necessary precautions in the event of a major storm.

3.0 ENGINEERING METHODS

For flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10, 50, 100, or 500 year period (recurrence interval) have been selected as having special significance for floodplain management and for insurance premium rates. These events, commonly termed the 10, 50, 100, and 500 year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one percent chance of annual occurrence) in any 50 year period is about 40 percent (four in ten), and for any 90 year period, the risk increases to about 60 percent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

Coastal inundation above the usual astronomic tide level from the Atlantic Ocean, caused by the passage of storms (storm surge), was determined using the joint probability method (Reference 9). The storm populations were described by probability distributions

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of five parameters that influence surge heights. These five parameters are central pressure depression (which measures the intensity of the storm), radius to maximum winds, forward speed of the storm, shoreline crossing point, and crossing angle. These characteristics were described statistically based on an analysis of storms that have passed near the southern coast of North Carolina. Primary sources of data for these analyses were the National Weather Service and the Mariners Weather Log. The National Weather Service provided information on tropical cyclones of the North Atlantic Ocean from 1871 to 1977, and on storms from 1886 through 1979 (References 10, 11, and 12). The Mariners Weather Log provided information on North Atlantic Tropical Cyclones in 1978 and 1979 (References 13 and 14). A summary of the parameters used for the Kill Devil Hills area is presented in Table 1, "Parameter Values for Surge Elevation."

Maximum wave crest elevations associated with the 10- and 100-year events were determined using the method recommended by the National Academy of Sciences (Reference 15). Further details are included in Section 3.3 of this study.

3.2 Hydraulic Analyses

Hydraulic analyses of the shoreline characteristics of the flooding sources studied in detail were performed to provide estimates of the elevations of floods for the selected recurrence intervals along each of the shorelines.

For areas subject to flooding directly from the Atlantic Ocean, the Federal Emergency Management Agency's standard coastal surge model was used to simulate the coastal surge generated by any chosen storm (that is, any combination of the five storm parameters previously defined). Performing such simulations for a large number of storms, each of known total probability, permits one to establish the frequency distribution of surge height as a function of coastal location. These distributions incorporate the large scale surge behavior, but do not include an analysis of the added effects associated with much finer scale wave phenomena such as wave height, set up, or run up. (The added effects associated with wave height were later analyzed and added to the stillwater storm surge elevations - see below.) The astronomic tide for the region is then statistically combined with the computed storm surge to yield recurrence intervals of total water level (Reference 16).

The surge model uses a grid pattern that approximates the geographical features of the study area. Simulations were first performed for the Kill Devil Hills area using an open coast grid having an element size of 5 nautical miles (nm). Surge is then propagated through a second 2 nm grid covering an extensive portion of coastal North Carolina including the outer barrier islands and the entire Albemarle Sound and Pamlico Sound systems. The 2 nm grid adequately represented the study area; therefore, no finer grid was constructed (Reference 16).

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Central Pressure Depression (millibars)	85	75	65	55	45	35	25	15	5
Probabilities:*									
I:	0.011	0.088	0.061	0.139	0.161	0.121	0.138	0.137	0.144
II:	0.011	0.089	0.060	0.143	0.159	0.119	0.139	0.136	0.144
III:	0.007	0.033	0.023	0.055	0.063	0.086	0.246	0.240	0.247

Storm Radius to maximum winds (nautical miles)	20	35
Probability	0.51	0.49

Maximum Forward Speed (Knots)	10	20	30
Probabilities:*			
I:	0.647	0.235	0.118
II:	0.396	0.377	0.226
III:	0.448	0.431	0.121

Crossing Angle (degrees)**	276	312	348	24	60
Probability	0.016	0.016	0.102	0.414	0.453
Rate (storms/nautical miles/year)	0.090 (10^{-3})	0.076 (10^{-3})	0.49 (10^{-3})	2.32 (10^{-3})	2.06 (10^{-3})

* I: Used for crossing angles 276°, 312°, 348°.
II: Used for crossing angle 24°.
III: Used for crossing angle 60°.

**Direction of forward motion, measured positive clockwise from true north.

TABLE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF KILL DEVIL HILLS, NC
(DARE CO)

PARAMETER VALUES FOR SURGE ELEVATION

9

NORTH CAROLINA COASTLINE NORTH OF HATTERAS INLET

Although northeasters (winter storms) are more diffuse and less intense than hurricanes, they occur more frequently and cover larger areas and longer coastal reaches at one time. The effects of northeasters were analyzed through a two step procedure. The first step was to perform a statistical analysis of the tide gauge data for winter storms at Hampton Roads, Virginia. The second was to develop a spatial correlation of the northeaster induced water elevations between Hampton Roads and each of the selected locations along the coast of the study through numerical model simulations.

The northeaster analysis led to two significant conclusions. First, the effects of northeasters on the 100-year storm surge elevations are significant only along the ocean side of the Outer Bank areas north of Cape Hatteras. Second, the effects are most significant in Currituck County where northeasters typically contribute between 1 and 1.5 feet to the 10-year surge elevations and generally less than 0.5 foot to the 100-year surge elevations. These contributions refer to the added effects of northeasters above surge computations which consider only the effects of hurricanes and other tropical storms plus astronomical tides.

3.3 Wave Height Analyses

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 15). This methodology is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in the Users Manual for Wave Height Analysis (Reference 17). The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 2, "Transect Location Map." The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

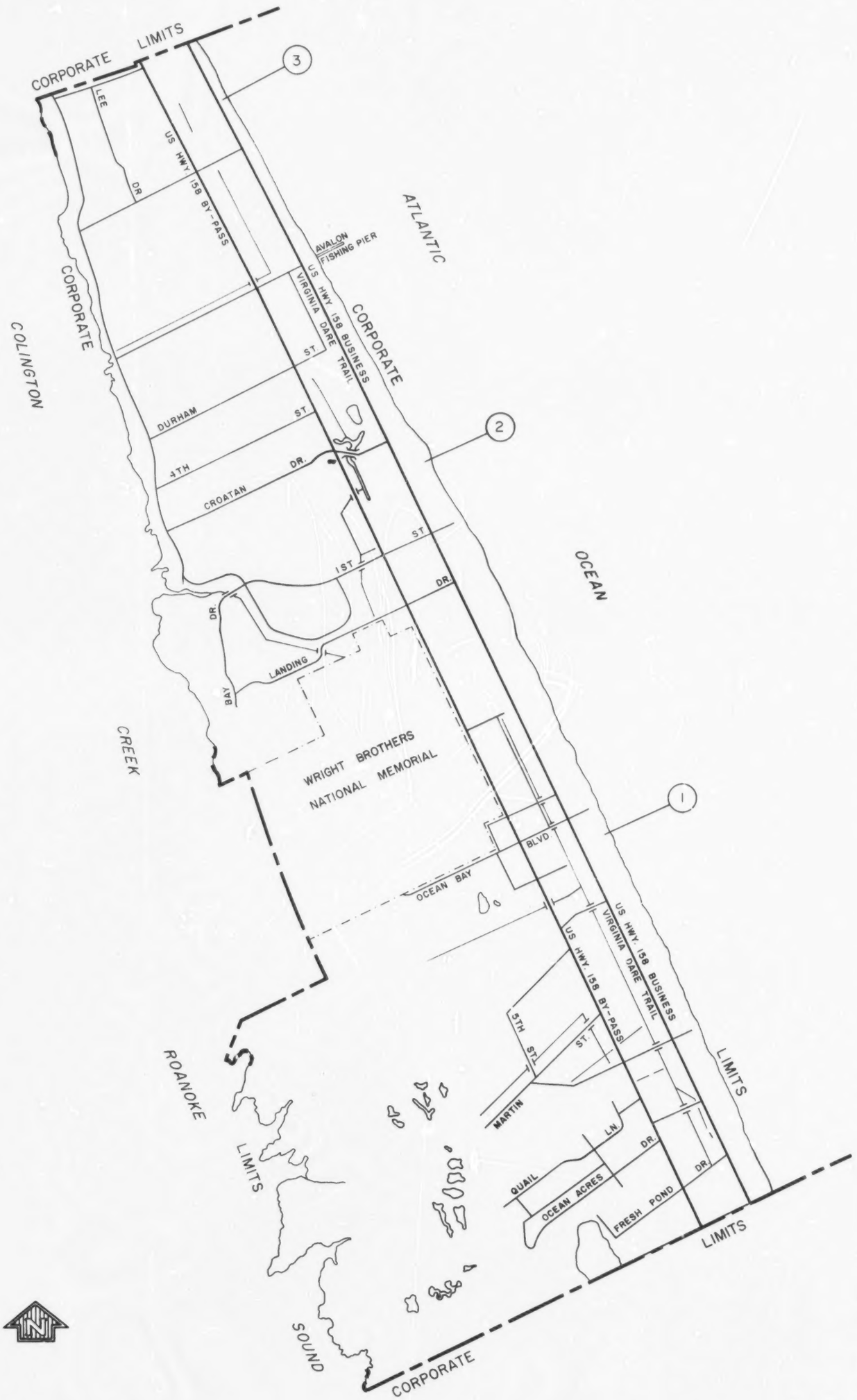

FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF KILL DEVIL HILLS, NC
(DARE CO)

APPROXIMATE SCALE
2000 0 2000 4000 6000 FEET

TRANSECT LOCATION MAP

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Each transect was taken perpendicular to the shoreline and extended inland to a point where wave action ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect.

Figure 3 is a profile for a hypothetical transect showing the effects of energy dissipation or regeneration on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations and being increased by open, unobstructed wind fetches. Actual wave conditions in the Town of Kill Devil Hills may not necessarily include all the situations illustrated in Figure 3.

During severe storms, beach erosion is expected to occur along the ocean shoreline of North Carolina. The methodology used to determine the effects of storm-induced beach erosion is described in the report by the North Carolina State University (Reference 18). The methodology is based on the concept that a beach profile which is in a condition of dynamic equilibrium during calm weather will approach a new equilibrium condition under elevated storm surges. The new equilibrium profile is determined by first calculating the depositional area which begins at the offshore limit of breaking waves, and then determining the erosional area such that it is exactly equal to the depositional area. A computer routine is used to apply the methodology to modify existing beach transects before wave height analyses are performed.

The storm-induced erosion expected to accompany a 100-year storm surge at each transect is provided in Table 2. The erosion distance given in Table 2 is measured from the existing shoreline to the landward limit of erosion, generally the toe of the eroded dune. Strictly speaking, the methodology applies only when overtopping of dunes by waves does not occur. Therefore, the values given in Table 2 may not represent all of the erosion that is expected in some areas.

Data for the model grid systems and the wave height calculations were obtained from U.S. Geological Survey quadrangle sheets (Reference 3), National Oceanic and Atmospheric Administration nautical charts (Reference 19), and from aerial photographs (Reference 20). The results of this study are considered accurate until local topography, vegetation, or cultural development undergo any major changes. The computed coastal surge and wave crest elevations for Kill Devil Hills are listed in Table 3, "Coastal Flood Insurance Zone Data" (see Section 5.2).

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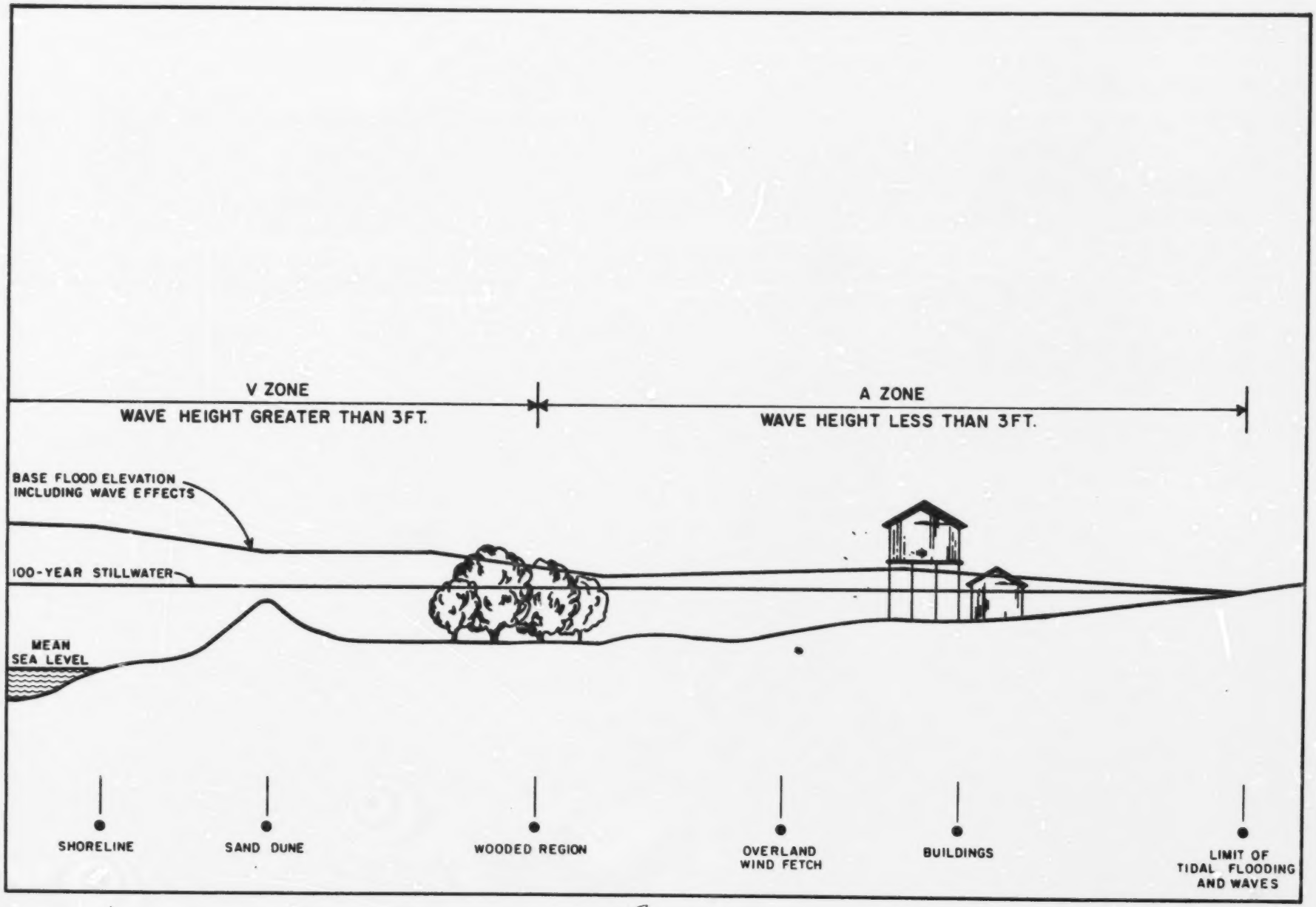

HYPOTHETICAL TRANSECT SCHEMATIC

FIGURE 3

COMMUNITY	PANEL[1]	TRANSECTS	100-YEAR STILLWATER (NGVD)	MAXIMUM WAVE CREST ELEV. (NGVD)	100 YEAR STORM[2] SURGE EROSION
Kill Devil Hills, Dare County	0001	1	7.6	11.8	79
	0002	2	7.8	12.1	90
	0003	3	7.8	12.1	92

1 FLOOD INSURANCE RATE MAP PANEL (FIRM)
2 DISTANCE IN FEET MEASURED FROM THE EXISTING SHORELINE

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TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF KILL DEVIL HILLS, NC
(DARE CO)

SHORELINE EROSION DATA

ATLANTIC OCEAN SHORELINE AT KILL DEVIL HILLS

All elevations are referenced to the National Geodetic Vertical Datum (NGVD) of 1929. Elevation reference marks used in this study are shown on the maps.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound floodplain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency as the base flood for purposes of floodplain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community.

The 100- and 500-year flood levels have been delineated using topographic maps at a scale of 1:24,000 with a contour interval of 5 feet (Reference 3). Aerial photographs at a scale of 1:24,000 were used as aids (Reference 20).

Flood boundaries are indicated on the Flood Insurance Rate Map. On this map, the 100-year flood boundary corresponds to the boundary of the area of special flood hazard (Zones A4 and V6), and the 500-year flood boundary corresponds to the boundary of the area of moderate flood hazard (Zone B). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown. The approximate study areas (A Zones) were delineated from previous Flood Hazard Boundary Maps (Reference 21).

Small areas within the flood boundaries may lie above the flood elevations, and therefore may not be subject to flooding. Owing to the limitations of the map scale, such areas are not shown.

4.2 Velocity Zones

The U.S. Army Corps of Engineers (Reference 22) has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones. This was based on a study of wave action effects on structures. This criterion has been adopted by the Federal Emergency Management Agency for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent floodplain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

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The location of the V Zone is determined by the 3-foot breaking wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot breaking wave.

5.0 INSURANCE APPLICATIONS

In order to establish actuarial insurance rates, the Federal Emergency Management Agency has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of Flood Hazard Factors (FHF), and the flood insurance zone designations for each flooding source affecting the Town of Kill Devil Hills.

5.1 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their assigned FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF is the average weighted difference between the 10- and 100-year flood water surface elevations expressed to the nearest one-half foot and shown as a three digit code. For example, if the difference between water surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water surface elevations is greater than 10.0 feet, the accuracy for the FHF is to the nearest foot.

In coastal areas where wave action affects flood hazards, the FHF of the V Zone is determined using the difference between the 10-year wave crest elevation and the 100-year wave crest elevation. This difference is estimated as being the difference between the stillwater elevations multiplied by 1.55. The numbered A Zone designations are determined by calculating the average difference between the 100-year stillwater elevation and the 10-year stillwater elevation for each zone. These differences are rounded to the nearest half foot to denote the FHF.

5.2 Flood Insurance Zones

After determining the appropriate FHFs, the entire incorporated area of the Town of Kill Devil Hills was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A: Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or flood hazard factors determined.

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Zone A4: Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to Flood Hazard Factors.

Zone V6: Special Flood Hazard Areas along coasts inundated by the 100-year flood, as determined by detailed methods, and that have additional hazards due to velocity (3 feet or more of wave action); base flood elevations shown, and zones subdivided according to Flood Hazard Factors.

Zone B: Areas between the Special Flood Hazard Area and the limits of the 500-year flood; areas that are protected from the 100-year or 500-year flood by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 3, "Coastal Flood Insurance Zone Data," summarizes the flood elevations, FHFs, flood insurance zones, and base flood levations for the flooding sources studied in detail within the Town of Kill Devil Hills.

5.3 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for Kill Devil Hills is, for insurance purposes, the principal result of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water surface elevation of the base (100-year) flood. This map was developed in accordance with the latest flood insurance map preparation guidelines published by the Federal Emergency Management Agency.

6.0 OTHER STUDIES

Other flood related studies that concern the study area include the Storm Tide Frequency Analysis for the North Carolina Coast by the National Oceanic and Atmospheric Administration (Reference 23); and the National Shoreline Study by the U.S. Army Corps of Engineers (Reference 24).

The previously published 100-year elevations in the above reference differ from those in this report. Discrepancies are the result of

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FLOODING SOURCE	PANEL[1]	TRANSECTS	STILLWATER ELEVATIONS				FLOOD HAZARD FACTOR	ZONE	BASE FLOOD[2,3,4] ELEVATION FEET (NGVD)
			10 YEAR	50 YEAR	100 YEAR	500 YEAR			
Atlantic Ocean	0001,0002 0003	1,2,3	5.7	7.2	7.7	9.3	030	V6	11-12
Atlantic Ocean/ Roanoke Sound/ Colington Creek	0001,0002 0003	N/A	7.3	8.7	9.3	10.7	020	A4	9

[1] FLOOD INSURANCE RATE MAP PANEL (FIRM)
[2] ROUNDED TO NEAREST FOOT
[3] DUE TO MAP SCALE LIMITATIONS, BASE FLOOD ELEVATIONS (BFEs) SHOWN ON THE FIRM MAY REPRESENT AVERAGE ELEVATIONS FOR THE ZONES DEPICTED
[4] MINIMUM AND MAXIMUM WAVE CREST ELEVATIONS, WHERE APPLICABLE

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF KILL DEVIL HILLS, NC
(DARE CO)

COASTAL FLOOD INSURANCE ZONE DATA

ATLANTIC OCEAN, ATLANTIC OCEAN/ROANOKE SOUND/COLINGTON CREEK

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differences in the hydrodynamic models and in the statistical analyses. The estimates provided herein follow the present Federal Emergency Management Agency methodology.

Flood Insurance Studies have been published for the Unincorporated Areas of Dare County and the Town of Nags Head (Reference 25 and 26). These studies are in agreement with this study.

A Flood Insurance Study for the Town of Kitty Hawk is in progress (Reference 27), and when complete, will be in agreement with this study.

Due to its more detailed analysis, this Flood Insurance Study supercedes the previously printed Flood Insurance Study for the Town of Kill Devil Hills (Reference 1).

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Office of the Natural and Technological Hazards Division, Federal Emergency Management Agency, 1371 Peachtree Street, N.E., Suite 736, Atlanta, Georgia 30309.

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